THE RELATIONSHIP BETWEEN THREE RIGHT HANDED PUNCH STYLES' IMPACT FORCE, AND SELECT FORCE, AND VELOCITY CHARACTERISTICS

Kristina M. Woodford[1], Michael R. Cahill[1], Daniel J. Hall[1], Hugh S. Lamont[1]
[1]Coastal Carolina University, Department of Kinesiology, Conway, SC, USA

INTRODUCTION: Over the last few years, boxing has increased in popularity as a sport and as a form of training. Boxing is primarily based on punching ability (i.e., speed and force) and overcoming an opponent. The overall objective in boxing is to knock the opponent out (KO) or stun the opponent enough that the referee does not deem them fit to continue (TKO). While punching does involve the movement of the arms to deliver the punch, the ability to incorporate the lower body in skilled performance allows for a more powerful punch (Turner, Baker and Stuart, 2011). The summation of force and resultant momentum comes from the larger proximal muscles and travels up the body (Nakano, Lino, Imura, and Kojima, 2014) out to the extremities containing the smaller distal muscles. Such proximal to distal sequencing has been referred to more generally as "kinetic linking" (Turner et al., 2011, Nakano et al., 2014). While traditional workouts for boxers have historically incorporated a large amount of aerobic based exercises, such as running, jump roping, and shadow boxing, there has been a drive to incorporate more sport specific based resistance training focused upon improving punch power and the resultant impact force (Guidetti, 2002, Musluini, and Baldari, 2011; Turner et al 2011; Lenetsky, Harris, and Brughelli, 2013; Loturco, Artioli, Kobal, and Franchini, E. 2014; Loturco , Bishop, Ramirez-Campillo, Romano, Alves, Pereira, and McGuigan, 2018).

Because boxers have a need for speed, power, and endurance, the optimal resistance training approach is still a topic of debate. Light load resistance training performed with 30-50% of 1 repetition maximum (1RM) and maximal movement intent coupled with moderate to high velocity movement has been shown to improve early stage (0-70ms) rate of force development (RFD) in moderately resistance trained subjects (Anderson, Anderson, Zebis, Aagaard 2011; De Oliveria, Rizatto, Denadi., 2013) and power in elite amateur boxers (Loturco et al., 2018). However, this type of training yields minor type 2 fiber hypertrophy and increases in maximal strength compared to strength training with heavy loads (Anderson at al., 2010; de Oliveria et al 2013; Grgic, Schoenfeld, and Latella., 2018). Such training has also produced increases in motor unit recruitment and doublet discharge frequencies effecting later stage RFD (70-200ms) (Anderson at al., 2010, de Oliveria et al., 2013, Grgic et al., 2018). Using a combination of bilateral and unilateral exercises across the force-power spectrum, exhibiting biomechanical specificity to "kinetic linking" during punching could prove to be valuable. Therefore, the purpose of this study was to determine the relationships between maximal force (Fmax), maximal power (Pmax), and maximal velocity (Vmax) recorded during select 1 repetition maximum (1RM) tests and three right hand punches (i.e., rear punch, jab, and rear hook).

METHODS: Thirty recreationally resistance trained college students (21 males and 9 females: 21.75±2.52 y, 176.29±11.75 cm, 89.39±22.63 kg) participated in this study. All participants read and signed informed consent and health history documents previously approved by Coastal Carolina University's Institution Review Board (IRB). Two testing sessions were performed on none consecutive days within a 5-day time period. Each session lasted up to 85 minutes in length. Day 1 of testing included height and weight (Detecto, Webb City, MO, USA), select body segment measurements, punching measurements and countermovement jump (CMJ) testing. Sport specific resistance exercise measurements were collected on Day 2. Exercises included 15° incline bench press lockout (BPL), unilateral split stance dumbbell push press (SSPP), and unilateral concentric start partial lunge (CSPL).

A Myotest Pro (Sion, Switzerland) tri-axial accelerometer was used to record Fmax, Pmax, and Vmax in trainer mode sampling at 500 Hz for each exercise during 1RM testing. The MyoTestPro placement was standardized between subjects to the left side of the bar for BPL and CSPL to minimize disruption to hand placement. Before exercises, the MyoTestPro was manually started, then stopped by the researcher at the completion of the exercise.

Countermovement jumps were performed with just body weight (CMJ), a 10 kg bar (CMJ10), and a 20 kg bar (CMJ20). A Bar Sensei (Oranchuk, Switaj, Robinson., 2016) accelerometer was used to measure Vmax at takeoff and was fixed on the right side of the bar. Maximal power output was then calculated from the estimated jump height (JH) from the Bar Sensei Vmax at takeoff using the calculation below: CMJ JH = $Vmax^2 / 2g$, where Vmax is CMJ takeoff (m/s) and g is the gravity constant ($9.81 \text{ m} \cdot \text{sec}^{-2}$). The resultant JH was then used to estimate the Pmax via the Sayers equation (Sayers, Harman, Frykman, Rosenstein., 1999).

The three punching styles assessed were the right-hand jab (RJab), right rear punch (RrPunch), and right rear hook (RrHook). Punching Fmax, Pmax, and Vmax was recorded via MyoTest Pro which was secured parallel in line with the application of force (i.e., punching surface) to a 113.64 kg Rival Banana punching bag. The accelerometer devices were secured via plastic clip (Myotest Pro) or a Velcro strap (BarSensei). Only Fmax was reported due to greater reliability and consistency in values reported across all 4 trials between all subjects. Participants wore Fighting Sport S2 Pro gel under gloves (2.5 oz.) and Rival boxing gloves (10 oz.) instead of wrapping the hands to save time and to provide an additional layer of protection to their hands. Verbal and physical instruction of how to perform punches were given by the same investigator. Subjects were instructed to "punch as hard as possible through the target." with peak impact force data collected from left and right arm's with only right arm data reported in the current study. Right handed punch styles were used as most participants reported being right handed (83%; n=25).

All Pearson correlations were performed using the SPSS software (SPSS version 24.0; IBM, New York, NY, USA). Assessment of correlation's practical magnitude was based off Hopkins r value classification's (Hopkins, Marshall, Batterham, & Hanin., 2009). The criteria used was trivial (<1.0), small (0.1 – 0.3), moderate (0.3 – 0.5), large (0.5 – 0.7), very large (0.7 – 0.9), or nearly perfect correlation (>0.9). Data were taken from the best two (Fmax) out of four punches then averaged.

TABLE 1. Relationship between righted handed punches and countermovement jumps

	Outcomes	CMJ V	CMJ10 V	CMJ20 V	CMJ P	CMJ10 P	CMJ20 P
Right Handed Jab	Pearson r	0.480**	0.481**	0.530**	0.672**	0.719**	0.728**
	p-value	0.008	0.008	0.003	0.00	0.00	0.00
	Magnitude	M	M	L	L	VL	VL
Rear Right punch	Pearson r	0.557**	0.527**	0.565**	0.683**	0.715**	0.720**
	p-value	0.002	0.003	0.001	0.00	0.00	0.00
	Magnitude	L	L	L	L	VL	VL
Rear Right Hook	Pearson r	0.664**	0.664**	0.640**	0.698**	0.743**	0.718**
	p-value	0.00	0.00	0.00	0.00	0.00	0.00
	Magnitude	L	L	L	L	VL	VL

*CMJ V = body weight counter movement jump peak velocity; CMJ10 V = 10 kg counter movement jump peak velocity; CMJ20 V = 20kg counter movement jump peak velocity; CMJ P = bodyweight counter movement jump peak power; CMJ10 P = 10kg counter movement jump peak power; CMJ20 P = 20 kg counter movement jump peak power; T: trivial; S: small; M: moderate; L: large; VL: very large; ** = correlation is significant at the 0.01 level.*

RESULTS: Moderate to very large correlations were found between all three punch types and the tested resistance exercises. The strongest correlations found between punch Fmax and CMJs were seen for CMJ20Pmax for the RJab, RrPunch, CMJPmax, and the RrHook (see Table 1). SSPP correlations were the strongest for 1RM for both RJab and RrPunch (Table 2). During CSPL strong correlations were found between both legs and RrPunch and 1RM (Table 2).

TABLE 2: Relationships between righted handed punches and sport specific resistance exercises

	Outcomes	BPL	Fmax	Pmax	Vmax	SSPP	Fmax	Pmax	Vmax
Right Handed Jab	Pearson r	0.778**	0.735**	0.121	-.534**	0.763**	0.718**	0.586**	-.075
	p-value	0.00	0.00	0.556	0.005	0.00	0.001	0.001	0.711
	Magnitude	VL	VL	S		VL	L	L	
Right Rear Punch	Pearson r	0.789**	0.769**	0.171	-.471*	0.718**	0.573**	0.594**	-.087
	p-value	0.00	0.00	0.402	0.015	0.00	0.002	0.001	0.666
	Magnitude	VL	VL	S		VL	L	L	
Right Rear Hook	Pearson r	0.812**	0.830**	0.308	-.356	0.691**	0.462*	0.431*	-.105
	p-value	0.00	0.00	0.126	0.075	0.00	0.015	0.025	0.603
	Magnitude	VL	VL	M.		L	M.	M	

	Outcomes	LCSPL	LF	LP	LV	RCSPL	RF	RP	RV
Right Handed Jab	Pearson r	0.691**	0.629**	0.441*	0.207	0.655**	0.549**	0.501**	0.205
	p-value	0.00	0.00	0.019	0.290	0.00	0.003	0.007	0.296
	Magnitude	L	L	M	S	L	L	L	S
Right Rear Punch	Pearson r	0.714**	0.668**	0.579**	0.314	0.701**	0.641**	0.411*	0.059
	p-value	0.00	0.00	0.001	0.103	0.00	0.00	0.030	0.766
	Magnitude	VL	L	L	M.	VL	L	M	T
Right Rear Hook	Pearson r	0.630**	0.570**	0.511**	0.266	0.608**	0.507**	0.429*	0.156
	p-value	0.00	0.002	0.005	0.171	0.001	0.006	0.023	0.429
	Magnitude	L	L	L	S	L	L	M	S

*BPL = 15° incline bench press lockout 1 repetition maximum; F = 15° incline bench press lockout max force; P = 15° incline bench press lockout peak power; V= 15° incline bench press lockout peak velocity; SSPP = Split stance dumbbell push press 1 repetition maximum; F = Split stance dumbbell push press peak force; P = Split stance dumbbell push press peak power; V = Split stance dumbbell push press peak velocity; LCSPL = Left leg forward unilateral concentric start partial lunge 1 repetition maximum; LF = Left leg forward unilateral concentric start partial lunge peak force; LP = Left leg forward unilateral concentric start partial lunge peak power; LV = Left leg forward unilateral concentric start partial lunge peak velocity; RCSPL = Right leg forward unilateral concentric start partial lunge 1 repetition maximum; RF = Right leg forward unilateral concentric start partial lunge peak force; RP = Right leg forward unilateral concentric start partial lunge peak power; RV = Right leg forward unilateral concentric start partial lunge peak velocity; T: trivial; S: small; M: moderate; L: large; VL: very large; ** = correlation is significant at the 0.01 level; * = correlation is significant at the 0.05 level.*

DISCUSSION: The moderate to very strong correlations highlighted between upper extremity and lower extremity, sport specific exercises, as well as loaded and unloaded CMVJ and Fmax during right handed punches suggest: 1) such tests could be incorporated into a monitoring program and; 2) potentially incorporated in to pre-competition, sport specific resistance training to substitute for more "traditional" methods historically used with the aim to more improve Fmax and Pmax punching characteristics.

The strongest correlations were found between punching Fmax and BPL 1RM and Fmax (range r = 0.735 to 0.830). The BPL was chosen to mimic the moment right before impact of a punch, to the follow through of the punch. The rationale was to attempt to reproduce similar forces as to those produced while "bracing" then punching through a target (Lenetsky et al., 2013). While the BPL is bilateral, the strong correlations suggest carry over to the unilateral action during linear and angular punches. The next strongest relationships were seen between punching Fmax and SSPP 1RM and Fmax (range r = 0.462 to 0.763). This test was performed from a split stance requiring subjects to perform a single arm push press. The semi ballistic nature of the push press in part mimics the tri-phasic pattern of activation-relaxation-activation utilized when "throwing" and then "landing a punch" (Turner et al., 2011, Loturco et al., 2014). As the push press is an expression of both high force and power utilizing "kinetic linking," it would seem distinct from the low velocity, high force, and partial range of motion BPL.

Correlations between CSPL and right-handed punches Fmax where slightly stronger for the left leg (range r = 0.570 - 0.714) 1RM and Fmax. This test was devised to mimic lead leg "plant" of "blocking" force seen when throwing rear hand punches from the right. The stronger correlations observed for loaded CMJ suggests the addition of external load, and the resultant reduction in take-off velocity is more strongly related to punching power and the resultant Fmax produced upon impact. The tests used in the current study appear to highlight differing kinetic and kinematics contributions to maximal punching. Future work should explore the incorporation of such unilateral dominant exercises during special preparation phases of training following basic and general preparation emphasizing predominantly bilateral based exercises for striking based athletes.

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